

IRMA: Interactivity and Multimedia for Mathematics

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***Abstract.** IRMA is a set of multimedia and software tools implemented to encourage the dissemination of scientific culture. On the basis of web technologies we have developed an environment to help learner approaching some mathematical topics, which become accessible through historical news, simulation and interactive applications. In this paper, we will explore the main design and implementation issues of IRMA project and how it can be used in a didactical activity.*

1. Introduction

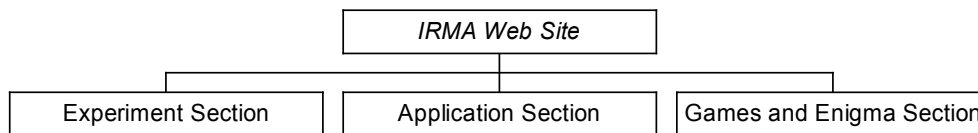
Students at secondary schools believe that “theory” is far from daily life and that some mathematical topics are rather tedious to be learned. The realisation of multimedia applications for the scientific dissemination would therefore play a fundamental role in the learning field, helping students in understanding the connection between theory and its application.

Through multimedia applications and interaction, by simulating natural phenomena, student is able to analyse and learn complex theories, also getting amused at it. Nevertheless, the realisation of multimedia applications for scientific dissemination may require a deep analysis of contents and didactical paths, in order to choose the best expository methodology which favours a higher learning and knowledge level.

IRMA is an Italian acronym for: “Interactivity and Multimedia for Mathematics”, whose aim is to offer people the possibility of focalising on some mathematical matters and applications starting from daily events intrinsically linked to not trivial results of the scientific research, in the conviction that it stimulates people’s curiosity and make them desire to go deeper into mathematics theories.

The final product of the project is a Web site. We intend, through it, to encourage and support the diffusion of the scientific culture, choosing an approach based on the integration of multimedia tools, Web and mathematical software.

The purpose of this paper is to give a description of *IRMA* both from the didactical and the technological points of view.



Picture 1. The main structure of *IRMA*.

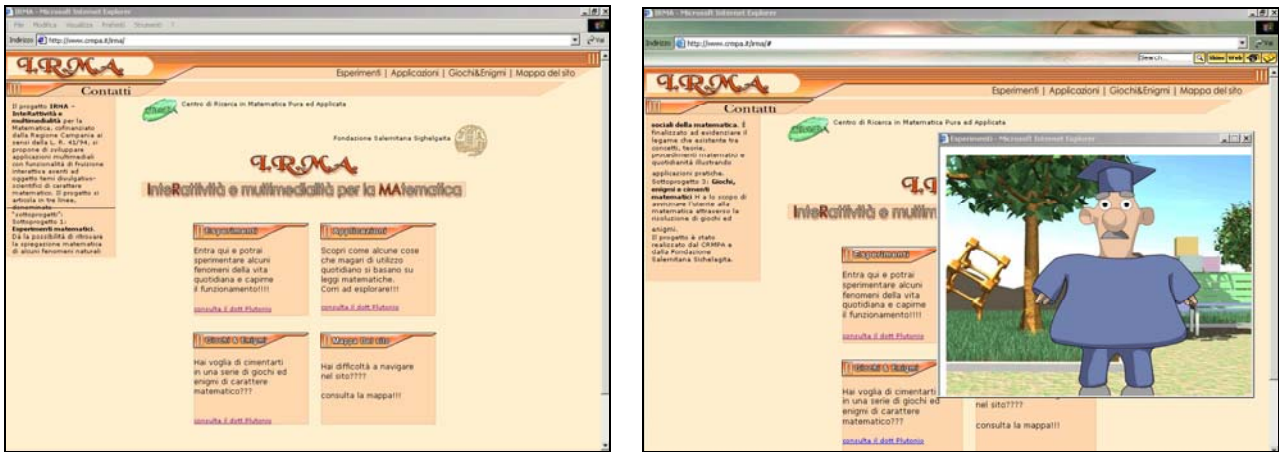
2. The *IRMA* Web site

The *IRMA* Web site [1] is structured into three different main sections as it can be seen above in the diagram in picture 1.

- *Experiment* is an interactive section in which students can enjoy some mathematical explanation of phenomena which are frequent in the real life and also interact with them. The study of Mathematics through the comprehension of natural phenomena is an easy way to attract people's attention, to stimulate their curiosity and interest even in the case of those who are not mathematicians but desirous to know the results of the scientific research in an intuitive way and to compare them with their own experience. Among the experiments included in this section we will find the rain drops falling and the little bubbles rising/mixing in a beer jug.
- *Application* is a section which gives learner the possibility to study some important applications of Mathematics in the real life, such as TAC, Cryptography and Diet. This section is finalized to point out the connections between concept, theory, Mathematics procedures and real life. In it, using a server side mathematical engine, it is possible to generate in real time answer to many problems like Diet and Tac. Besides, through the contribution of Applets and JavaScript, the student can experiment other kind of applications.
- *Games&Enigma* section, is conceived to host and sort according to the matters, a series of questions and mathematical enigmas. It makes use of the game as learning experience, stimulating the students' curiosity and desire to approach Mathematics. Common strategy - games are chosen, such as classic logic questions and typical combinatory problems.

The following chapters will deal with a description of the above sections. In particular, a double side view is given for each of them. First of all, the section is seen from the user's point of view i.e. what the user sees and how he can exploit what he sees. But also the developer's point of view is discussed i.e. which technology underlies the section and how it can be carried out.

Before starting the discussion about *IRMA* sections, some words must be spent on the adopted user interface. Picture 2a shows two instances of the web site home page.



Picture 2. IRMA user interface: the home page, home page and Professor Plutonio.

The first instance is obtained when a user opens the web address, [1]. As it can be seen, an header shows the site logo and some buttons allowing the access to all the other sections. Through this header, the possibility to switch from one section to another is given at any time, avoiding disorientation or the feeling to get lost in the site.

As for the second instance, it is worth to say that according to the modern pedagogical theories, a right methodological approach, and as a consequence a right user interface, must take into account different kind of metaphors: icons and conversation. For this reason, the picture of *Professor Plutonio* has been created. It represents an assistant/tutor who introduces users into various sections composing a sort of “scientific park”.

Each section, as you may observe in picture 3, (a page from the *Experiment* section), is composed of more than one page, so to avoid the user’s disorientation, besides the header, a structured menu containing a line for each topic of the section (see box 2 in picture 3) is placed on the left of the user’s screen. In this way the user is able to know, at any time, which is his position in the web site.



Picture 3. IRMA user interface: A generic page with header (1) and its section topic menu (2).

Finally, if the student needs to know the structure of the web site, he can click on the site map specific link, which he find on the header.

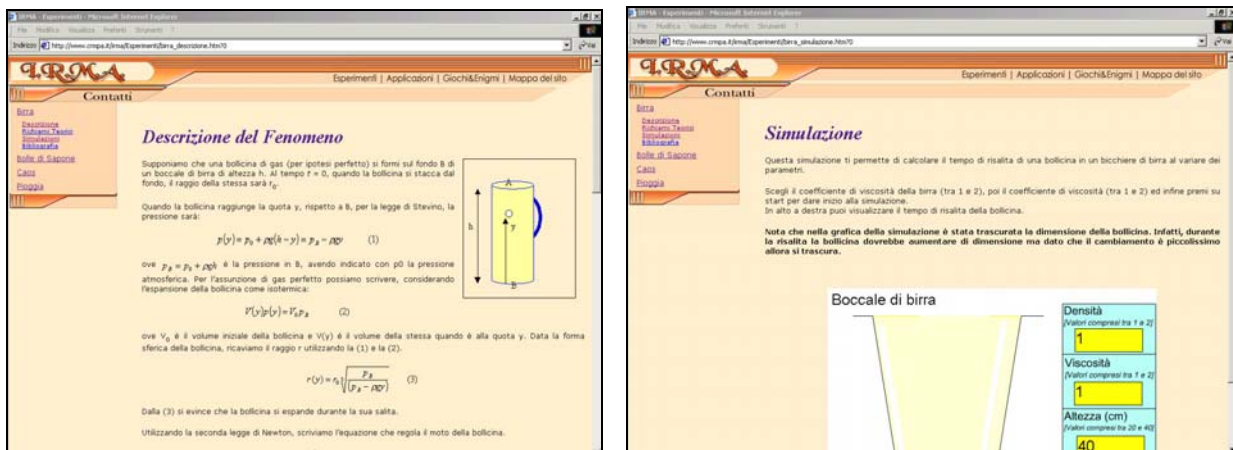
3. The Experiment Section

In the *Experiment* Section, starting from friendly questions, the student will find answers to simple questions concerning such mathematical and physical background of natural phenomena, for instance: the time spent by a bubble to go up in a jug of beer; why if someone blows in a soap lamina he produces a spherical bubble; how to study a chaotic phenomenon such as an atmospheric phenomenon; why the rain drop is not spherical; which is the speed of a rain drop falling.

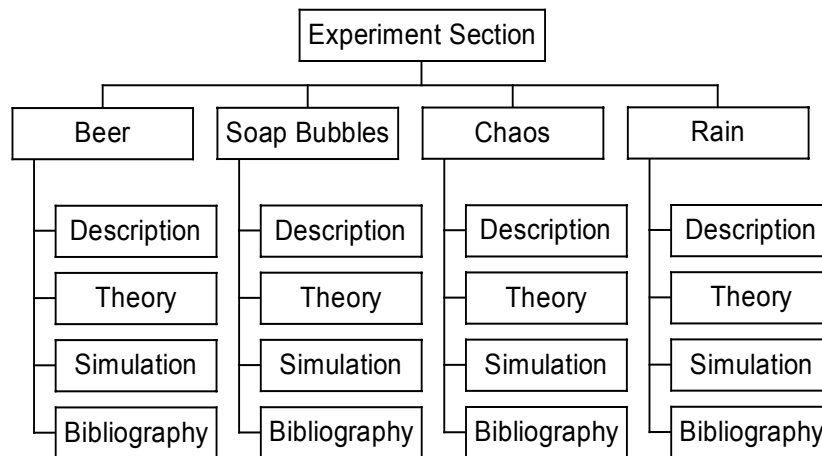
We have chosen these phenomena for their natural simplicity in the real life, aware that they would interest any type of person and not only those who have already a scientific knowledge.

Picture 5 describes the structure of the whole *Experiment* section. Please note that each natural phenomenon considered has its subsection, whose general structure is composed of four pages:

- *Description* – in which the main characteristics of the phenomenon are presented through simple questions.
- *Theory* – in which the student is able to learn about the mathematical and physical background. The didactical material has been organised in topics which students can access to by clicking on the corresponding link buttons.
- *Simulation* – in which the student can interact with the phenomenon in question.
- *Bibliography* – in which the student can find a list of web addresses and articles on the subject of interest.

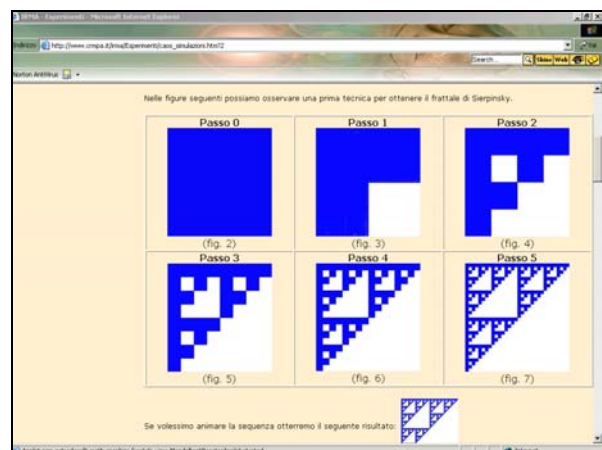
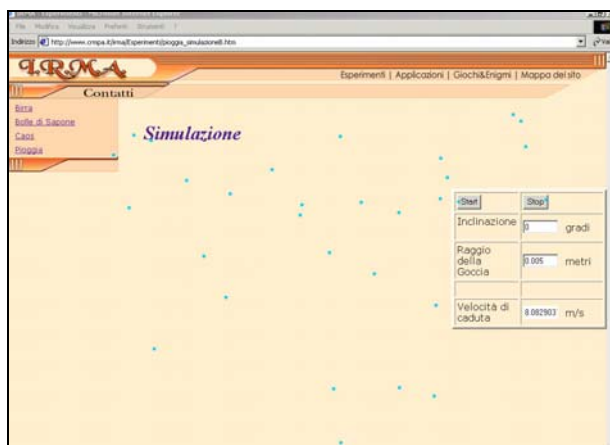


Picture 4. Selected images of *Experiment* Section: Description of *Beer* phenomenon; Simulation of *Beer* phenomenon.



Picture 5. The structure of Experiment Section

In Picture 4, and better in picture 6, namely, the *Beer* subsection - *Simulation* page, is showed how the learner can interact with an application [2] where, by modifying the values of the beer viscosity, the beer density and the glass height, it is possible to visualize the bubble moving/ rising in the glass and the time it requires for it.



Picture 6. Other images selected from the Experiment Section: Rain Simulation page; Chaos Simulation page.

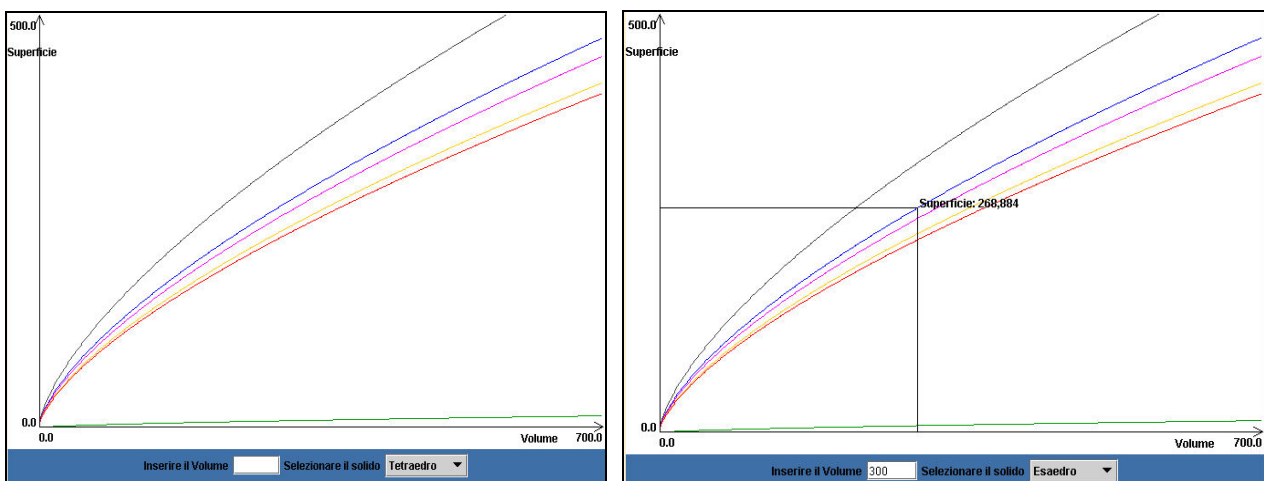
In the *Rain* Simulation page, Picture 6, learner interacts with a javascript [3], in which as much the rain inclination and the drops ray vary, as the drops speed is automatically calculated and a set of drops appear on the user's screen.

In the *Chaos* Simulation page, the learner visualises, through an animated image, the various steps to the Sierpinsky Triangle. Starting from the blue square, picture 6, he is expected to remove a little square whose side is the half of the initial square, obtaining three squares. Then, from each of these latter, adopting the same technique, he removes another square in the right lower part, obtaining nine little squares, and keeps on removing until he gets the final result.

In the *Soap Bubbles* Simulation page, Picture 7, the learners interact with a Java Applet to get to know why the soap bubbles have a spherical shape. Mathematically that is true since among

surfaces containing the same volume, the sphere is the smaller one. Through a Java Applet the learner inserts a volume value and chooses among six polyhedral. The Applet, at this point, will represent graphically on the curve, the intersection point between the chosen polyhedron and the introduced volume.

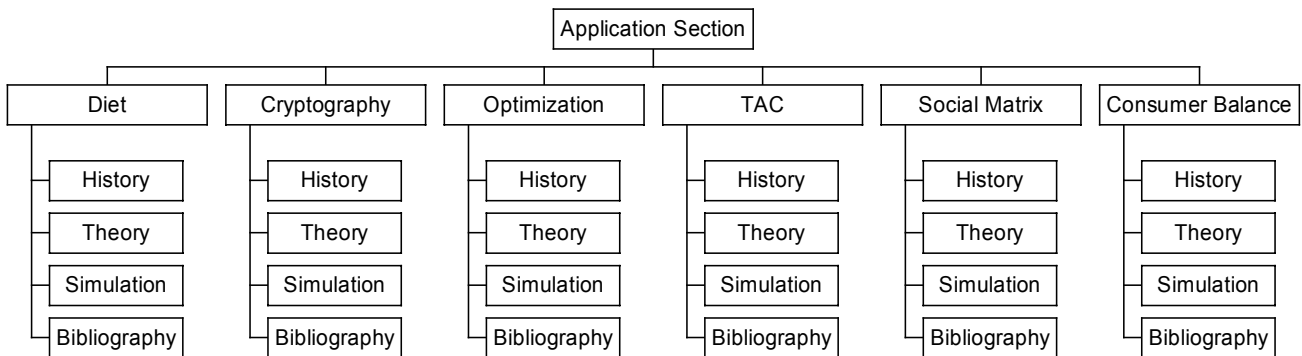
In detail, as we see in picture 7, the Applet realizes a system of Cartesian axis in which six curves are drawn. On the x-axis it is represented the polyhedron Volume, on the y-axis its surface. Each curve represents the rate between the volume and the surface of a regular polyhedron. On the bottom, the learner finds a text box, where he can insert a volume value, and a combo-box, where he can choose one polyhedron among the following: *Sphere*, *Icosahedra*, *Dodecahedron*, *Octahedron*, *Hexahedron* e *Tetrahedron*. After having inserted the value and selected the polyhedron, the applet will calculate the related value of the chosen polyhedron surface and will visualize the rate on the curve.



Picture 7. Soap Bubble Simulation: As it appears by default ; as it changes inserting 300 as volume and selecting, as polyhedron: an *Hexahedron*.

4. The Application Section

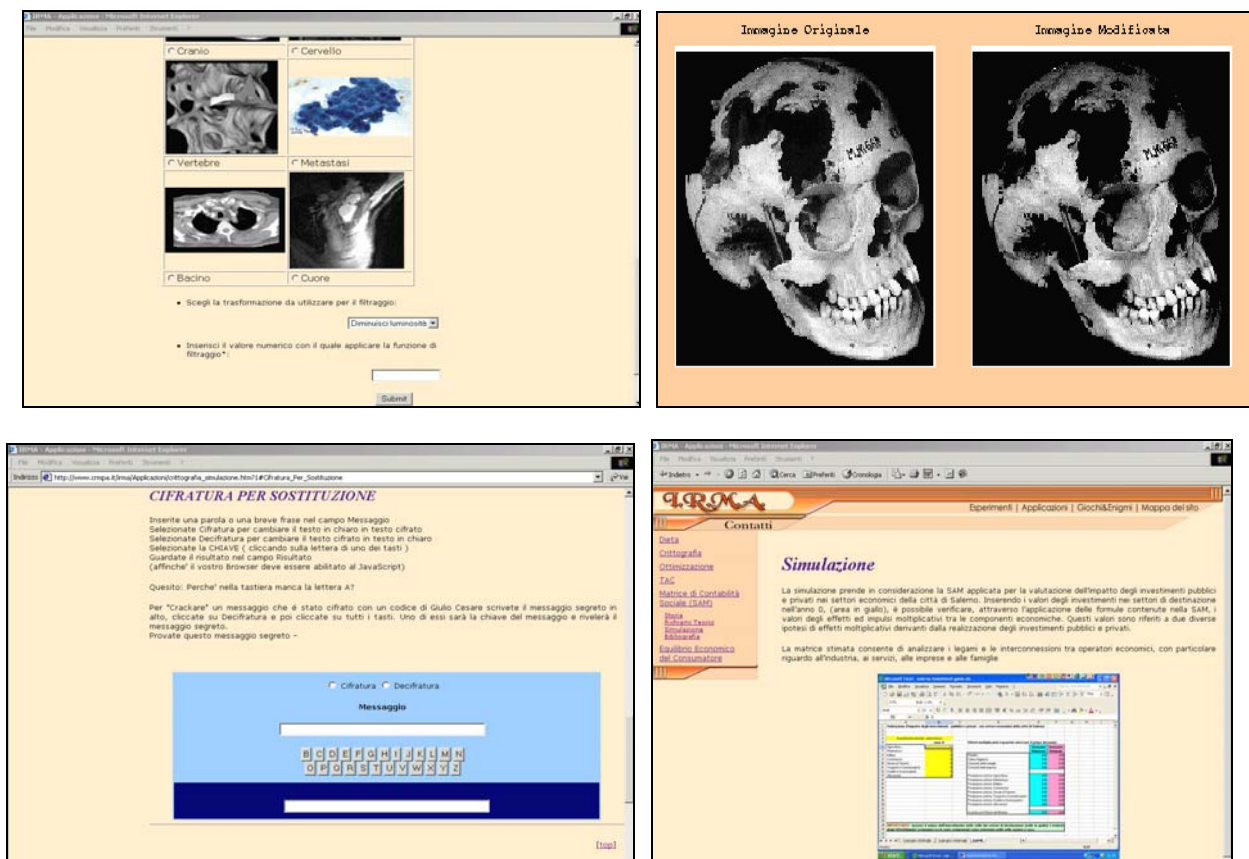
The *Application* section contains a collection of mathematical applications to the real life. Particular attention has been given to applications like *Diet* or *TAC*, which seem have not a mathematical background.



Picture 8. The structure of Application section.

In Picture 8, the section structure is the same as the one in the *Experiment* section, except for the *Description* page, which has been substituted by the *History* page, presenting a related brief historical scenario. For this section as well, in the *Simulation* subsection, students interact with an implemented application in order to let them not only study theory but also practise.

In the *Diet* section, the student learns why the diet problem [5] is a simple linear programming problem [4]. Particularly, in the *Theory* subsection, he can learn what the linear programming and the Simplex Method are; in the *Simulation*, he can interact with a simple experiment in which by simply choosing some kind of food and its daily price, and specifying the daily minimum requirements of calories, proteins and fats, the application calculates the diet that minimizes the costs.



Picture 9. Images from the Application section: TAC Simulation page; the result of TAC application; Cryptography simulation page; Consumer Balance Simulation Page.

In the *TAC* section, student is given the possibility to understand how TAC is carried out thanks to the representation of human body thin thickness (axial tomography) and of X rays absorption statistical evaluation (computerized). In the *Simulation* subsection, the student can interact with a simple experiment on images filtering. Particularly choosing an image between those available and deciding the type of filter to use, the application returns both the original image and the filtered one, picture 9.

To realise the applications in the *TAC* and *Diet* sections, we used the mathematical engine *Mathematica 4.1™ Kernel* by Wolfram Research [11].

To interface such engine with the Web site, we used *WebMathematica*: a server-side application based on Java Servlet, applications able to extend a Web server with facilities for the dynamic generation of HTML pages.

In our applications, when student inserts the right parameters and presses the **Submit** button, data will be posted to a Servlet running on the server machine. Such Servlet (MSP Servlet) take a particular page (MSP page), that is required by the HTTP request. This page loads a *Mathematica* package and executes it (associating parameters collected from the client) communicating with the *Mathematica Kernel* and running concurrently on the same machine. MSP page is parsed by Servlet and when in the page there is Mathlet tag, his content is passed to Mathematica and its result is placed on the page. The initial MSP page is transformed by Servlet in a HTML page and sent to the client browser.

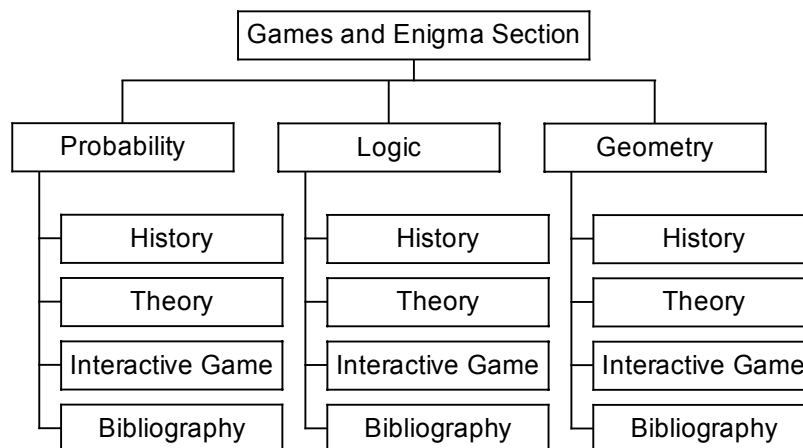
5. The Games & Enigma Section

In the *Interactive Space* section, student can enjoy himself by solving questions and mathematical enigma on Probability [7], Logic [8], [9] and Geometry, [12].

The games are all interactive, therefore, it is possible to verify the reply exactness simply and immediately. They show a lovely design and are provided with theoretical recalls to allow student to study in depth or to help himself in the understanding of the solutions.

The Picture 10, shows the Games & Enigma structure. It visualises three sections, one for each topic. The main subsection is the *Interactive Game*, where student finds a list of links, each related to a particular game.

As reported in Picture 11, the student chooses for each question among three or four answers and, clicking on it, verifies the correctness of his answer. In case of the right answer a proof will be presented.



Picture 10. The structure of Games & Enigma section.



Picture 11. Images from the Games & Enigma Section: Choose a card (A), who says the truth (B) the perimeter of a triangle (C).

All applications in this area are implemented with Flash MX. Flash MX is a powerful tool to develop Multimedia applications that can also be executed in a Web Browser. The student interacts with applications that are Flash films. These applications are embedded in the HTML pages. When students request this kind of page, the Web Server takes the page and send it to the Client Browser. Then the browser will visualize the film and the student will interact with it.

6. Conclusions

In this paper we meant to present *IRMA*: an interactive tool conceived to encourage and support the dissemination of scientific culture through the integration of multimedia, Web and mathematical software. Specifically, we gave a double side view of *IRMA* components taking into account both users and developers' needs.

We point out that *IRMA* is running on our Web server and can be reached at the URL specified in [1]. You can address any question and / or comment about the site itself or this paper as well, to the site administrators (the authors of this paper).

References

- [1] <http://www.crmipa.it/irma> .
- [2] R. De Luca, *Una bollicina in un boccale di birra*.,
- [3] R. De Luca, *Una gocciolina che cade dalle nuvole*.,
- [4] http://utenti.lycos.it/big/programmazione_lineare .
- [5] <http://www-fp.mcs.anl.gov/otc/Guide/CaseStudies/diet/formulation.html> .
- [6] Pozzi R. *Trattato italiano di Tomografia computerizzata*. Vol 1/3.1996
- [7] <http://web.tin.it/ABC/descsi/giochi.html>
- [8] <http://utenti.lycos.it/prometeo/pagina7.htm>
- [9] Franco Agostini, *Le stravaganze della logica – Giochi, aneddoti, paradossi e teorie per allenarsi a pensare*, Mondadori
- [10] B. Eckel. *Thinking in Java*. MindView Inc., 1997.
- [11] S. Wolfram. *The Mathematica Book - third edition*. Cambridge University Press, 1996.
- [12] <http://www.mclink.it/personal/MC5834/giochi.htm>